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Corrigendum

The image published on the back page of the most recent issue of *The Victorian Naturalist* (volume 136, no. 1) was incorrectly captioned, below the Table of Contents. The caption should have been 'Dingo (*Canis familiaris* dingo), captive individual photographed at Territory Wildlife Park, Darwin. Photo P Menkhorst.' The Editors apologise to both Jeff Yugovic, author of the relevant article, and Peter Menkhorst, who supplied the photograph.

The Victorian Naturalist

Volume 136 (2) 2019 April

Editors: Gary Presland, Maria Gibson, Sue Forster

Editorial Assistant: Virgil Hubregtse

Research Report

Daily and seasonal calling activity of the Growling Grass Frog *Litoria raniformis* in northern suburban Melbourne, *by Brendan Casey, Jeff Shimeta and Jeff Hughes* 64

Contributions

The Little Pied Bat *Chalinolobus picatus*: a confirmed addition to the mammal fauna of Victoria, *by Sally Bewsher, David De Angelis and Knud Hansen* 70

Connecting the dots of simultaneous extinctions: *Tchuteba*, Yam Daisies and Aboriginal cultivation, *by Ian Mansergh and David Cheal* 78

Naturalist Note

Ants collecting pieces of a bird dropping at Notting Hill, Victoria, *by Virgil Hubregtse* 85

Book Reviews

Night Parrot: Australia's most elusive bird, *by Penny Olsen, reviewed by Michael Weston* 88

Plants of the Victorian High Country: a field guide for walkers, *by John Murphy and Bill Dowling, reviewed by Maria Gibson* 90

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Front cover: Growling Grass Frog *Litoria raniformis*, Western Treatment Plant, Werribee, Victoria. Photo John Harris (see p. 64)
Back cover: White-footed ants. Photo Virgil Hubregtse (see p. 85)

Daily and seasonal calling activity of the Growling Grass Frog *Litoria raniformis* in northern suburban Melbourne

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Abstract
Acoustic recorders were used during spring, summer and autumn of 2017–2018 to try to record the call of a threatened frog species, the Growling Grass Frog *Litoria raniformis*. Calling was recorded at three sites along the northern urban boundary of Melbourne, Victoria. *Litoria raniformis* calls were recorded most frequently from an old quarry hole, followed by a pool in the Merri Creek and then from a stormwater settling pond. The first *L. raniformis* call was recorded during late September 2017 and the last in early February 2018. The majority of *L. raniformis* calls were recorded nocturnally throughout October, November and December 2017, although the timing of the calling activity varied across the three sites. This study found the automated operation of the recorders assisted in identifying the nocturnal call behaviour of *L. raniformis*. (*The Victorian Naturalist* **136**(2), 2019, 64–69)

Keywords: Growling Grass Frog, *Litoria raniformis*, frog calls, Merri Creek

Introduction

The Growling Grass Frog *Litoria raniformis* is a listed threatened species (Department of Environment and Energy [DEE] 2018; Department of Susutainability and Environment [DSE] 2013) from south-eastern Australia. *Litoria raniformis* has undergone a recent and well-documented range contraction (Heard *et al.* 2012; Pyke 2002; Schultz 2008; Wassens 2008), no longer being documented in the ACT nor in most of its former range across NSW, and experiencing a substantial decline across much of Victoria (Clemann and Gillespie 2012). The main threats to *L. raniformis* include habitat loss or habitat degradation and Chytrid Fungus ***Batrachochytrium dendrobatidis***, the water-borne pathogen responsible for the infectious disease Chytridiomycosis that affects amphibians worldwide (DEE 2018).

Litoria raniformis has been documented from natural habitats where extant populations persist (DEE 2018; Heard *et al.* 2004), constructed wetlands and places not designed as frog habitat (Clemann and Gillespie 2012; Heard *et al.* 2008; Heard *et al.* 2012; Koehler and Gilmore 2014; Wassens 2008). *Litoria raniformis* calls while floating in water or from land adjacent to water (Littlejohn 1963; Pyke 2002), and the calling period is reported to be from September to February (Pyke 2002) and August to April (Brook 1980; Hero *et al.* 1991). The probable breeding season is from October to December (Brook 1980). *Litoria raniformis* has a diphasic advertisement call (Thomson *et al.* 1996), described as a long introductory note, or growl, followed by two or three short grunts (Littlejohn 1963; Thomson *et al.* 1996), and four call types have been recognised (Ford 1989).

This paper describes the recorded daily calling activity of *L. raniformis* at two artificial ponds near Merri Creek and a pool in Merri Creek located within the outer northern suburbs of Melbourne. The *L. raniformis* population in the Merri Creek catchment is considered to be a large and important metapopulation (Clemann and Gillespie 2012). The results were used to develop an understanding of the daily and seasonal timing of *L. raniformis* calling activity at the three recording sites.

Method

Study area

The study area (Fig. 1) was on the northern fringe of the Melbourne urban boundary, within the suburbs of Craigieburn, Somerton and Epping. The three bioacoustic monitoring sites were in different habitat types, adjacent to Craigieburn Grassland Nature Conservation Reserve, although none were within gazetted reserves. The three sites were not hydrologically connected; however, there was no physical barrier between the sites.

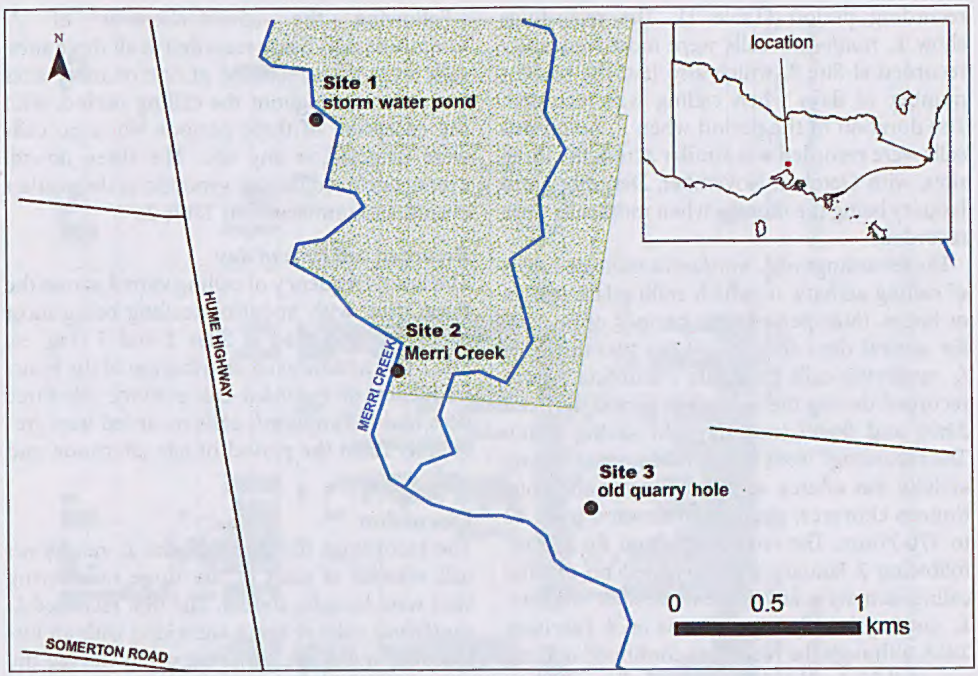

Fig. 1. Location of the three *Litoria raniformis* acoustic monitoring sites in northern suburban Melbourne.

Site 1 (–37.6175°, 144.9549°) was a storm-water pond site perched above nearby Merri Creek and recharged from a relatively small industrialised catchment of approximately 400 hectares. It was positioned between a looming tilt-slab construction and Merri Creek.

Site 2 (–37.6294°, 144.9587°) was a pool in Merri Creek downstream of the Craigieburn Sewage Treatment Plant outfall, where partly tertiary-treated effluent discharges into Merri Creek. The pool was one of a series of pools separated by riffles along the creek.

Site 3 (–37.6361°, 144.9684°) was an old quarry hole located within Epping Organic Resource Recovery Facility. Up to 6 ML of water is pumped from nearby Merri Creek each spring to provide an aquatic habitat to support the existent *L. raniformis* population.

Site 1 is located 1.3 km north of Site 2 and on the western side of the creek. Site 3 is 1.1 km south-east of Site 2 and on the east side of the creek. Site 1 is less than 100 m from the nearest point along Merri Creek and Site 3 is 150 m from Merri Creek.

Equipment

The instruments used to record the frog calls were Song Meter 4 (SM4) type acoustic recorders. The recorders were attached to a post or tree trunk above the flood-line, within a few metres of the potential calling habitat.

The recorders were left unattended to automatically record for the first ten minutes of every hour at each site. A summary of the recording dates are in Table 1. The recorders were serviced about every two months to inspect their condition and replace the batteries and memory cards. Recording ended sooner than planned when earthworks began at Site 1 and the instrument was taken from Site 2.

Each ten-minute audio file was played in the acoustic software package Kaleidoscope Viewer, to determine if any *L. raniformis* calls were captured in the recording.

Results

Recorded calling activity

The SM4 recorders operated in an unbroken recording sequence for the duration of the

recording period (Table 1). The recordings show *L. raniformis* calls were most frequently recorded at Site 3, which also had the highest number of days when calling was recorded. The duration of the period when *L. raniformis* calls were recorded was similar across the three sites, with October, November, December and January being the months when most calls were recorded.

The recordings of *L. raniformis* indicate cycles of calling activity, in which calling lasted days or hours, interspersed with periods of no calls for several days (Fig. 2). About two-thirds of *L. raniformis* calls from Site 1 and Site 3 were recorded during the nocturnal period between 22:00 and 06:00 (non-daylight saving time). The recordings from Site 2 indicate that calling activity was often a series of discrete and continuous choruses, ranging in duration from 40 to 170 hours. The recordings from the period following 7 January 2018 revealed no diurnal calling activity at any of the three sites. The final *L. raniformis* call recorded was on 4 February 2018, although the recorders continued operating until 25 April 2018.

Following the commencement of *L. raniformis* calls being recorded at all three sites, calls were then recorded at one or more sites every day throughout the calling period, with the exception of three periods when no calls were detected at any site. The three no-call events occurred during synoptic-scale weather events, as summarised in Table 2.

Recorded call time of day

The hour-frequency of calling varied across the three sites, with nocturnal calling being most frequently recorded at Sites 1 and 3 (Fig. 3). Site 2 had a more even distribution of the hour-frequency of recorded call activity. All three sites had *L. raniformis* calls recorded least frequently from the period of late afternoon and early evening.

Discussion

The recordings indicate that the *L. raniformis* call seasons at each of the three monitoring sites were broadly similar. The first recorded *L. raniformis* calls at Site 3 coincided with an unseasonal warm spell that occurred during the period 21–23 September 2017 (Bureau of Mete-

Table 1. Summary of recording dates and *L. raniformis* calls recorded.

	Sites		
	1	2	3
Recording start date	15 Aug 2017	17 Sep 2017	17 Sep 2017
Recording end date	25 Apr 2018	25 Apr 2018	25 Apr 2018
First *L. raniformis* call recorded	14 Oct 2017	16 Oct 2017	23 Sept 2017
Last *L. raniformis* call recorded	4 Feb 2018	23 Jan 2018	21 Jan 2018
Files with *L. raniformis* recorded/ total files	428 / 6049	740 / 5281	1007 / 5281
Days *L. raniformis* recorded/ total recording days	55 / 243	59 / 219	99 / 219

Table 2. Summary of weather events during which *L. raniformis* calls ceased across the three sites.

Sites	Date of no calls recorded	Duration of no calls (hours)	Weather event concurrent with no calls recorded
1	21 Oct to 23 Oct 2017	63	Passage of a cold front across south-eastern Australia
2	1 Dec to 4 Dec 2017	64	Passage of a trough, low pressure system and cold front
3	6 Jan to 8 Jan 2018	57	Blocking high pressure system over the Tasman Sea

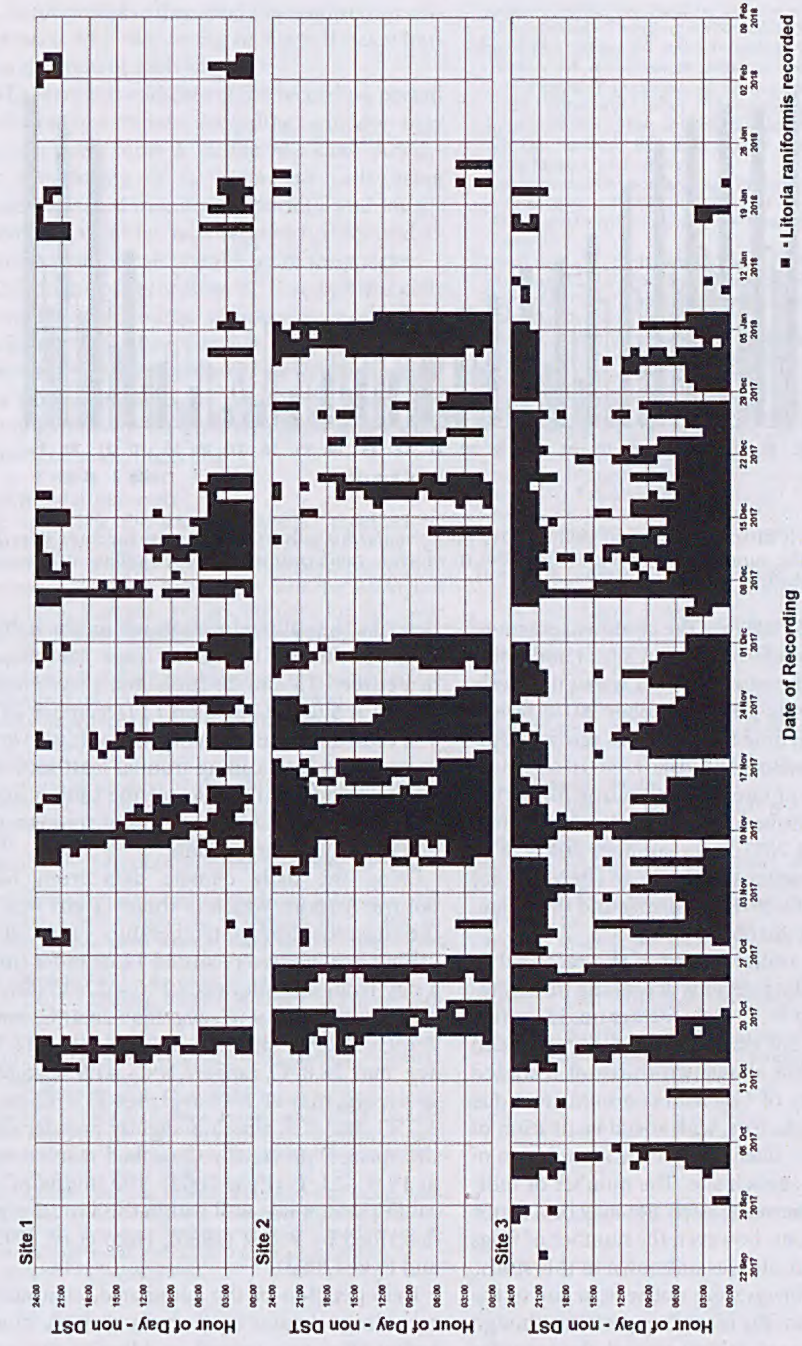

Fig. 2. *Litoria raniformis* hourly calling activity recorded between 22 September 2017 and 9 February 2018.

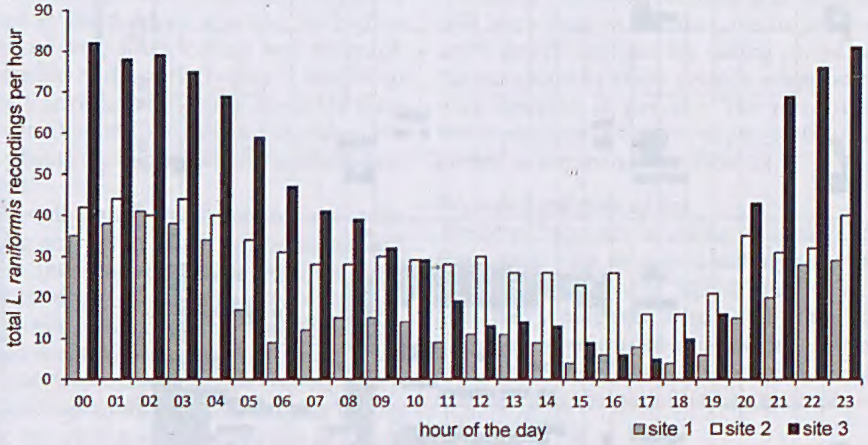

Fig. 3. The hourly distribution of daily calling activity of *L. raniformis* calls recorded across the three sites. The vertical axis is the number of ten-minute audio files in which *L. raniformis* was recorded calling at least once at that hour of the day.

orology [BoM] 2017a). The commencement of recording *L. raniformis* calls at Sites 1 and 2 also coincided with the arrival of a warm northerly airstream during 16–18 October 2017, resulting in high daytime temperatures across Greater Melbourne (BoM 2017b).

The climate of Greater Melbourne for spring 2017 was described as drier and warmer than average (BoM 2017c), for summer 2017–18 as warmer and wetter than average (BoM 2018a) and for autumn 2018 as warmer and drier than average (BoM 2018b).

The pattern of the timing of the recorded *L. raniformis* calling periods across the three sites may be due to local-scale factors not identified in this study. For example, Brooke *et al* (2000) determined that about two-thirds of recorded calling activity of *Cophixalus ornatus* was due to small-scale factors, with social facilitation of calling males a likely trigger for stimulation of calling males at each site. The number of individual *L. raniformis* at each site may be a factor in call behaviour; however, the number of frogs present at each site was unknown in this study.

Litoria raniformis were not seen at any of the sites throughout the recording period, although calling was heard during two of the recorder service visits. Therefore, it is not possible to describe the calling location within the habitat or the position of the calling frogs. An estimate of between 15 and 20 individuals were heard calling at Site 3 at 09:00 on 13 December 2017. The estimate is based on hearing at least two or more individuals calling from at least six locations. Despite searches to see the calling frogs, they remained hidden from view amongst the emergent Cumbungi plants.

Using the daily climate data from Melbourne Airport, which is about 11 km west of the sites, the average temperature range when calling activity was recorded 12 or more times a day from any site was 12 °C– 27 °C (Site 1: n=9, avg. min 11.9 °C, avg. max 26.4 °C, range 7.5 °C–31.6 °C; Site 2: n=30, avg. min 13.6 °C, avg. max 28.0 °C, range 7.2 °C– 41.5 °C; Site 3: n=41, avg. min 11.1 °C, avg. max 25.7 °C, range 3.7 °C–38.3 °C), which is slightly broader than the species' previously described active range of 15 °C–23 °C (Pyke 2002). The timing of the calling season was well within the annual range described by Brook (1980), Hero *et al.* (1991) and Pyke (2002).

The operation of the automated, continuous recording schedule used across multiple monitoring sites was crucial to identify the nocturnal call activity and different call times of

L. raniformis. Further study is required to understand why the timing of the call behaviour was different at each site.

The start and end date of the recording period and the ten-minute recording window may have missed some *L. raniformis* calls. Acoustic monitoring of *L. raniformis* calls using larger seasonal monitoring periods and longer recording windows may support further understanding of the call phenology of the species.

Selections of recordings of *L. raniformis* calls from this bioacoustic monitoring study were archived with the National Film and Sound Archive, Canberra (**https://www.nfsa.gov.au/**). For public access to the recordings, search the catalogue by typing 'growling grass frog' in the catalogue search text box.

Acknowledgements

We appreciate the financial support provided by RMIT University. This project was funded by the Holsworth Wildlife Research Endowment—Equity Trustees Charitable Foundation and the Ecological Society of Australia. We are thankful for the assistance provided by many volunteers during site visits, in particular Gary Hardy and Holly Casey. Hume City Council and City of Whittlesea permitted access to the two off-creek habitats. Anonymous reviewers greatly improved the quality of this report.

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The Little Pied Bat *Chalinolobus picatus*: a confirmed addition to the mammal fauna of Victoria

Fauna Survey Group Contribution No. 30

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Abstract
A general fauna survey was carried out by the Fauna Survey Group of the Field Naturalists Club of Victoria in spring 2014 in the Yarrara and Mallanbool Flora and Fauna Reserves in north-west Victoria. During this survey, four individuals of the Little Pied Bat *Chalinolobus picatus* were trapped in Yarrara Flora and Fauna Reserve. No previous trapping records of this species have been made in Victoria. All four individuals were lactating or pregnant females, suggesting that a resident breeding population occurs in the area. The capture represents an approximate 50 km range extension for the species from the previous nearest reliable record, at Wentworth in New South Wales. (*The Victorian Naturalist* **136**(2), 2019, 70–77)

Keywords: *Chalinolobus picatus*, Belah woodland, range extension, Yarrara Flora and Fauna Reserve, Victoria

Introduction

Yarrara Flora and Fauna Reserve (FFR) covers approximately 2262 ha and is located along and near the Red Cliffs – Meringur Road about 70 km west of Mildura, in north-west Victoria. The reserve was gazetted in May 1979 (Parks Victoria 2015) for the protection of the largest remaining stands of Belah *Casuarina pauper* woodland in Victoria (Murray Catchment Management Authority 2012). Mallanbool FFR is a smaller (518 ha) reserve approximately 10 km south-east of Yarrara, supporting similar vegetation. Both reserves are located within the southern part of the Murray-Darling Basin of south-eastern Australia, a semi-arid region which experiences hot, dry summers and mild winters (Lumsden and Bennett 1995).

At its closest, Yarrara FFR is approximately 11 km north of Murray-Sunset National Park. It is surrounded in all directions principally by largely treeless farmland in which cereal crops predominate. Remnant Belah woodland and mallee are largely limited to roadsides.

Approximately 20 bat trapping surveys had previously been undertaken from the northern Murray-Sunset area to the New South Wales border between 1985 and 2008, with 14 species recorded (Department of Environment, Land, Water and Planning [DELWP] 2016). Bat trapping at Yarrara FFR took place between 1985 and 1987, consisting of at least three surveys undertaken by the Department of Conservation, Forests and Lands (DELWP 2016). The current bat survey appears to be the first to have been undertaken there in the past 27 years.

The Little Pied Bat *Chalinolobus picatus* (Gould, 1852) is a member of the family Vespertilionidae. It has been trapped or observed relatively infrequently compared to most other bat species that occur in eastern Australia (Atlas of Living Australia [ALA] 2017).

The current known range of Little Pied Bat includes parts of southern and central Queensland, much of non-coastal New South Wales and a small area of far eastern South Australia north of the Murray River (ALA 2017). It occurs mostly in arid and semi-arid areas in a variety of forests, woodlands and shrublands (Thomson *et al.* 1999; Office of Environment and Heritage [OEH] 2017). There have been no previous confirmed capture records of the species in Victoria. However, there is one record of a sighting in the Atlas of New South Wales Wildlife from Mildura (OEH 2015). Various possible records of its echolocation call from Murray-Sunset National Park (Humann 2009) and Neds Corner Station (Rowe and Roberts 2012) require confirmation.

The national conservation status of Little Pied Bat was originally considered to be Near Threatened by Thomson *et al.* (1999), but more recently was judged to be of Least Concern because the rate of population decline is probably less than previously thought (Woinarski *et al.* 2014). The species is currently listed as Near Threatened on the IUCN Red List of Threatened Species (Ellis and Pennay 2008). It is listed as Least Concern in Queensland under the Nature Conservation Act 1992, but as Endangered in South Australia under the National Parks and Wildlife Act 1972 (Version 1-7-2015) and Vulnerable in New South Wales under the Threatened Species Conservation Act 1995. The species is not listed as threatened under Australia's Environment Protection and Biodiversity Conservation Act 1999. Its conservation status in Victoria is yet to be assessed.

The Little Pied Bat is easily distinguishable from other bats in the south-west of its range by its shiny black fur above, slightly lighter coloured fur below and two distinctive white stripes along the undersides of the body, next to the wing membranes (Churchill 2008) (Fig.1). It has been found to roost in a wide variety of places (Churchill 2008), with the number of individuals recorded using a single roost varying from one (Dominelli 2000) to less than 100 (Woinarski *et al.* 2014).

Methods

Fauna surveys of the Yarrara and Mallanbool Flora and Fauna Reserves were carried out by the Fauna Survey Group of the Field Naturalists Club of Victoria (FNCV) over five days in late September and early October 2014 in conjunction with Parks Victoria (Drury and Antos 2016).

Harp traps (Austbat/Faunatech, Mount Taylor, Victoria, two-bank traps, area of each bank 185 × 224 cm) were used to survey for

Fig. 1. Female Little Pied Bat captured at Yarrara Flora and Fauna Reserve in October 2014, showing characteristic white stripes along the underside of the body next to the wing membrane. Photo Mark Antos.

bats. Bat trapping took place in Yarrara FFR (three areas), Mallanbool FFR and in the grounds of the Meringur Community Centre. One night of trapping was devoted to each of the five areas. The number of traps set in an area varied from two to four, resulting in a trapping effort of 13 trap nights in total.

Except for one site in Yarrara FFR, which was in mallee woodland, all sites were in Belah woodland of varying structure and quality. Trap sites were chosen by looking for potential flyways, such as along tracks or where there were gaps in the vegetation. They were generally situated a short walk from a road or vehicle track. The distance between traps was mostly between 50 and 100 m, but those in Mallanbool were up to about 2.5 km apart.

Traps at Yarrara Areas 1, 2 and 3 and at Meringur were set up for approximately 13 hours (between 1800 and 0700 hrs), while those at Mallanbool were set up for only three hours (between 1900 and 2200 hrs) due to the travel time involved. In most cases, the traps were set up in a new area each evening. No traps were erected on 30 September due to gale force winds, so traps were set up in two areas on 1 October.

The maximum daily temperatures at Lake Victoria, approximately 42 km north of the study area, were between 21 °C and 32 °C during the survey period. Three days prior to the start of the survey 6 mm of rain was recorded at Meringur (Bureau of Meteorology 2015). However, by the time of the survey there was no sign of recent rain in the study area and the ground was dry and dusty.

All traps were checked at about 2200 hrs and any individuals caught were identified, weighed, and released. The traps were checked again at around dawn and all captures were placed into calico bags and taken to the campsite for processing. This involved identifying the species, weighing each bat, recording its sex and measuring the forearm. The bats were kept in the bags in a cool building during the day, before being released on dusk that evening at the site of capture. Individuals were not marked, therefore recaptures could not be determined.

A channel which weaves its way through Yarrara FFR and across the surrounding landscape is part of a former extensive irrigation channel system which stretched between Red Cliffs to the east and Morkalla to the west of Meringur. Some parts of the channel are still clearly visible and accessible, providing a potential flight path for bats, while others are collapsing or hidden by trees, shrubs and fallen limbs. One trap was set in the channel. The channel was dry in the vicinity of the trap at the time of the survey, although it is not known whether the remainder of the channel was entirely devoid of water. In the past, water was pumped into the channel system from the Murray River via Lake Cullulleraine during the cooler months of the year. The pump station and channel were decommissioned in 1974 and replaced by the Millewa Pipeline (Engineers Australia 2016).

The main vegetation present at several Victorian locations where Little Pied Bats have possibly previously been recorded was ascertained either from the literature or determined using Google Maps imagery.

Results

There was a total of 34 bat captures from at least four species. Bats were trapped in all survey areas except Meringur (Table 1). *Vespadelus* spp. were not identified to species level. The two morphologically similar species whose distributions overlap in the region (Inland Forest Bat *V. baverstocki* and Southern Forest Bat *V. regulus*) can be difficult to distinguish in the field, even with examination of key features such as the shape of the glans penis (L Lumsden pers. comm. 2015). An additional species, the White-striped Freetail Bat *Austronomus australis*, which has an audible echolocation call, was detected at one site. Bat trapping was most successful on the night of 1 October, when a total of 21 bats was captured, including four Little Pied Bats.

The single trap in which all four Little Pied Bats were caught was located in the old irrigation channel in Yarrara Area 2 (Fig. 2). It was erected in a section of the channel which was clear of fallen logs and vegetation (Fig. 3).

Biological data for the four Little Pied Bats captured are shown in Table 2. All were females, three of which were lactating (nipples were swollen and hairless), while the fourth, heavier bat was pregnant. One individual was retrieved during the late evening trap check, while the

Table 1. Results of bat surveys in Yarrara, Mallanbool and Meringur in spring 2014. * = Traps were taken down at 2200 hrs at Mallanbool. # = The echolocation call of *Austronomus australis* was heard, but no individuals were caught.

	Survey area					Total
	Yarrara Area 1	Yarrara Area 2	Yarrara Area 3	Mallanbool	Meringur	
Date traps set	29 Sept 2014	1 Oct 2014	1 Oct 2014	2 Oct 2014	28 Sept 2014	
No. of trap nights	4	2	2	*3	2	13
Species						
Gould's Wattled Bat *Chalinolobus gouldii*			2			2
Little Pied Bat *Chalinolobus picatus*		4				4
Lesser Long-eared Bat *Nyctophilus geoffroyi*	1	2	3	1		7
Forest Bats *Vespadelus* spp.	9	3	8	1		21
White-striped Freetail Bat *Austronomus australis*					#1	#1
Total for site	**10**	**9**	**13**	**2**	**#1**	**35**

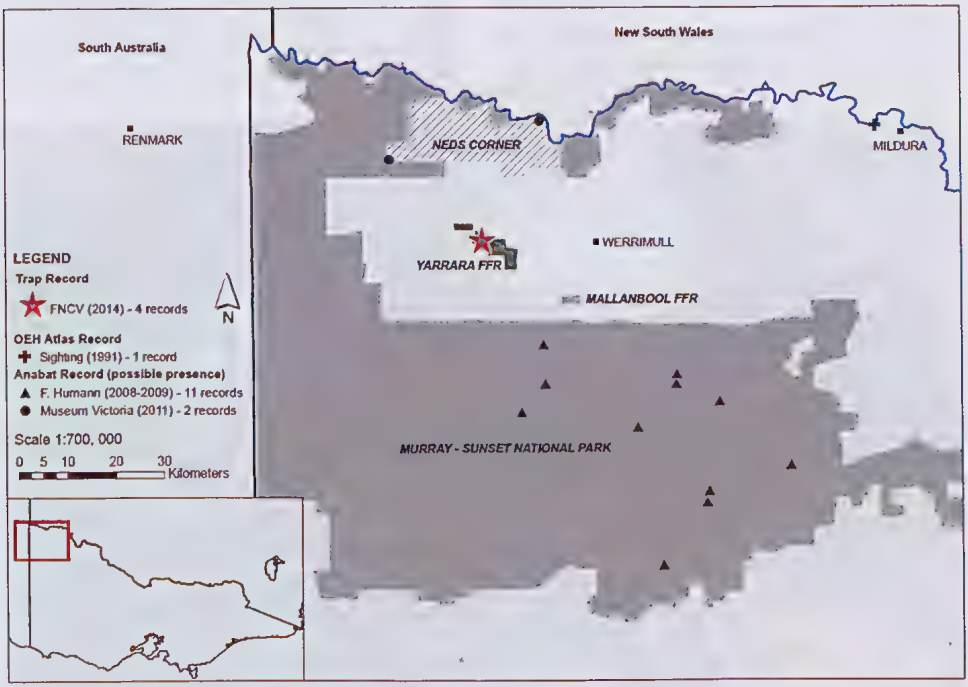

Fig. 2. Location of the study area in north-west Victoria. The successful trap site is shown, as are the Victorian locations in the surrounding region where possible call recordings and sightings of the Little Pied Bat have been made.

Table 2. Biological data for the Little Pied Bats *Chalinolobus picatus* trapped

Individual	Sex	Weight (g)	Forearm length (mm)	Reproductive condition
1	Female	6.1	34.5	Lactating
2	Female	6.0	34.2	Lactating
3	Female	8.4	35.1	Pregnant
4	Female	7.6	Not recorded	Lactating

remaining three were found the following morning. A voucher specimen was not taken.

The site was located approximately 80 m from cleared farmland at the northern edge of the reserve. The vegetation in the general proximity of the site was semi-arid woodland dominated by scattered mature trees of Belah in variable condition, and a small group of dead Slender Cypress-pines *Callitris gracilis* subsp. *murrayensis* over 12 m high. The understorey consisted of various scattered taller woody plants (e.g. Sugarwood *Myoporum platycarpum*), small shrubs including Woody Cassia *Senna artemisioides* subsp. *petiolaris* and grasses such as Spear-grass *Austrostipa* spp. The channel itself was approximately 4 m wide at the top of the bank, with a depth of 0.8 m, and flanked on each side by semi-continuous belts of vegetation spaced approximately 5 m apart. These consisted principally of closely-spaced, small (15-20 cm diameter) Belah stems to 10 m high. The top of the trap was set approximately 4 m above the base of the channel.

Discussion

The capture of four individuals of Little Pied Bat in the Yarrara FFR in October 2014 is significant for Victoria, as it confirms the occurrence of the species in the state.

The Atlas of NSW Wildlife includes one sighting of the species in Victoria made by an employee of the NSW National Parks and Wildlife Service beside the Murray River near Mildura in April 1991 (OEH 2015). The native vegetation at this

Fig. 3. Trap site where Little Pied Bats were captured in the central part of Yarrara Flora and Fauna Reserve, showing the decommissioned channel and surrounding vegetation. Photo Sally Bewsher.

location is Black Box *Eucalyptus largiflorens* woodland with a chenopod understorey. This location is approximately 70 km east-north-east of Yarrara FFR.

Unconfirmed acoustic (Anabat) recordings of Little Pied Bat made at two sites on the Neds Corner Bush Blitz in 2011 (Rowe and Roberts 2012) were located approximately 25–30 km north of the successful trap site at Yarrara FFR. One was in riverine vegetation (Bush Blitz 2011), while the other was in chenopod shrubland with a mallee overstorey. Call recordings of varying certainty were also obtained by Humann (2009) at 12 of 36 sites representing various post-fire age classes (pre-1972-2008) across approximately 600 sq km of mallee vegetation in Murray-Sunset National Park. The sites ranged from approximately 20 –80 km south to south-east of Yarrara FFR. The calls recorded by Humann (2009) were classified as unconfirmed due to a lack of previous records from this area and an overlap in call characteristics with the sympatric Little Broad-nosed Bat *Scotorepens greyii*. The Little Pied Bat can often be distinguished from the Little Broad-nosed Bat with more certainty when the pulses alternate (Pennay *et al.* 2004). Ellis and Henle (1988) reported locating Little Pied Bat during winter by hearing audible calls and using a spotlight to identify them and seeing their distinctive white-shaped markings.

All Victorian records, whether unconfirmed recordings of echolocation calls or the sighting reported in the Atlas of NSW Wildlife (OEH 2015), have been made in the last 25 years. It is possible that anthropogenic climate change or other factors responsible for habitat alteration over time may be causing a southward extension of the range of the Little Pied Bat and that the species will consequently be recorded more often in Victoria.

A record from west of Wentworth, NSW, in 1986 of a number of individuals found roosting in a shed (M Schulz cited in Lumsden and Bennett 1995) is the closest confirmed record to the Yarrara captures. The Yarrara captures therefore represent a range extension of approximately 50 km for the species. Another record in NSW somewhat further from Yarrara FFR is that of an individual trapped in a citrus orchard at Gol Gol, NSW about 5 km north-east of Mildura (D Gee pers. comm. 2015). More distant locations in south-west NSW where the species has been recorded include Mallee Cliffs National Park, Tarawi Nature Reserve, Scotia Sanctuary and the Willandra Lakes area (Tidemann 1988; Dominelli 2000; FNCV unpubl. data 2000; Val *et al.* 2012; ALA 2017).

The species is also known to occur in South Australia at Danggali Conservation Park, Gluepot Reserve and Calperum Station (Dominelli 2000). Almost all of the South Australian records are within 200 km of Yarrara FFR (ALA 2017).

The vegetation in Yarrara FFR is similar to some of that within Dominelli's study area in the Riverland Biosphere Reserve, South Australia, where two Little Pied Bats were radio tracked and found to be roosting in the hollows of dead Belah and Sugarwood (Dominelli 2000). The species is also known to roost in caves and mine shafts (at first believed to be its only roost sites) (Richards 1995), elevated eucalypt hollows (Pennay and Freeman 2005), dead mulga *Acacia aneura* (M Pennay, pers. comm., cited in Churchill 2008), under decorticating bark (Richard and Marston 2010), in sheds (Reardon and Flavel 1987; Lumsden and Bennett 1995; Dominelli 2000), in the walls of old buildings (Richards 1979) and in a boulder pile (M Pennay, pers. comm., cited in Churchill 2008). The Little Pied Bat can use multiple roosts, with one individual radio-tracked in Belah woodland found to use four different roosts over a period of five nights (Dominelli 2000).

Given that four breeding females were caught in the same trap on the same night and that not all were caught at the same time, it is very likely that they came from a resident breeding population. No attempt was made to identify roost sites beyond taking a casual interest in possibilities near to where the bats were caught. For example, large, old, dead Slender Cypress-pines containing fissures and cavities were present close to the trap site, as were dead and mature Belah.

There were no buildings in the immediate vicinity of the successful trap, but some were located on nearby farms and at Meringur township within 1 km and 4 km respectively of the trap site.

The Little Pied Bat is capable of flying long distances to forage, with individuals in Bourke, NSW, having been recorded flying 17 km one-way from a roost site (M Pennay pers. comm. cited in Churchill 2008). It is not known whether such a distance is typical or exceptional for the species. The likelihood that the roost location of the individuals trapped at Yarrara FFR was outside the reserve appears to be low, however, given that four lactating or pregnant individuals were captured on one night in the same trap.

The presence of lactating females appears to be particularly early in the season (Drury and Antos 2016) and 3–4 weeks earlier than previously reported (Churchill 2008). It is also one to two months earlier than has been recorded for other species in the region where details of breeding patterns were documented in the 1980s (Lumsden and Bennett 1995).

Factors which may adversely affect the suitability of Yarrara FFR and habitat beyond for Little Pied Bats include predation by cats and foxes (OEH 2017; Woinarski *et al.* 2014) and the consequences of wildfires (Dominelli 2000) such as direct mortality, loss of hollows and other roosts, and reduced foraging opportunities. While mallee vegetation is highly flammable (Parsons 1994), Belah woodland is fire-resistant (Dominelli 2000). However, with few exceptions, woody species in Belah woodlands, including Belah itself, are killed when fire occurs there (Sluiter *et al.* 1997).

Adjacent to Yarrara FFR, there appears to be little regeneration of isolated paddock trees which may provide roost sites for Little Pied Bats. Such trees are thus unlikely to be replaced once lost, unless done via planting and then would be likely to take decades if not centuries to develop hollows. Additionally, such trees are permitted to be removed, subject to approval, under Victoria's native vegetation removal guidelines (DELWP 2017).

Other threats identified as possibly having impacted the Little Pied Bat elsewhere in its range include overgrazing by native and introduced herbivores, altered fire regimes, mining (Dominelli 2000), the application of agrichemicals (Woinarski *et al.* 2014), water point removal (Dominelli 2000; Woinarski *et al.* 2014) and the removal of, or damage to, old buildings (Thomson *et al.* 1999).

Additionally, the species may be negatively impacted by anthropogenic climate change in northern Victoria due to the increased probability of wildfire, increased frequency of extreme heat events, and drought. The Loddon-Mallee Region including far north-west Victoria is projected with high-very high confidence to experience higher average temperatures and less rainfall by 2030 than at present (DELWP 2015). Mildura currently has an annual average of 36 days with a maximum temperature greater than 35°C. This figure is expected to rise to 46 days by 2030 and to between 54 and 66 days by 2070. Harsher fire weather, including an increase in the number of very high and extreme fire danger days is also projected (DELWP 2015). In addition, because there will very likely be a substantial increase in the temperature reached on hot days (DELWP 2015), there may be an increased likelihood of direct mortality of the Little Pied Bat due to extreme heat. While the species is known to occupy roosts in which the temperature can sometimes exceed 40°C (Turner 2004), information obtained by Bondarenco *et al.* (2014) suggests that individuals have died as a result of heat wave conditions. Finally, it is projected with medium confidence that time spent in drought is likely to increase over the course of the twenty-first century (DELWP 2015). This may lead to a reduction in available open water in the landscape, which is a requirement for the Little Pied Bat in hot, dry environments (OEH 2017).

It is recommended that more trapping be undertaken to gather further information on the distribution and population size of the Little Pied Bat in northern Victoria, particularly in areas of confirmed and unconfirmed records. However, improved future information and/or survey techniques may allow for greater certainty in the identification of Little Pied Bat using acoustic methods. Further investigation is also required to determine the types of roosts used by the species in the area.

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Connecting the dots of simultaneous extinctions: *Tchuteba*, Yam Daisies and Aboriginal cultivation.

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Abstract
Once widespread in south-eastern Australia, the White-footed Rabbit-rat (*Conilurus albipes*) became extinct across its entire range soon after European settlement, with the last known living example from Victoria recorded from central and western areas of the colony in the mid 1840s. Its biology, ecology and distribution remain ill-defined. It appears to have been restricted to the fertile soils associated with what we now describe as 'woodlands'. The economies and agricultural practices of Indigenous communities saw the preferential cultivation of grasses and tubers in the fertile woodland habitat of *C. albipes*. We consider that the over the millennia this vegetarian rodent had evolved an obligate association with such cultivation, particularly the Murnong or Yam Daisy *Microseris* sp (p). Extinction of either adversely affected the other. *Conilurus albipes* was a totemic animal for some indigenous language groups in south-eastern Australia and probably a food resource. (*The Victorian Naturalist* **136**(2), 2019, 78–84)

Key words: White-footed Rabbit–rat, *Conilurus albipes*, *Microseris* spp., Indigenous agriculture, GunaiKurnai, Ngarigo and Wolgal

Introduction

Four Indigenous language groups in south-eastern Australia had the White-footed Rabbit-rat as a totem — *Tchuteba*. Totem status indicates that it had *particular* significance in the social organisation, economic and spiritual life of these Indigenous peoples, who also had a high reliance on the Yam daisy in their diet. European diseases ravaged Indigenous populations. Subsequently, exotic livestock, particularly sheep, preferentially grazed and destroyed the traditional owners' fertile and cultivated lands. The Yam Daisy and other plants cultivated as vegetable staples by Indigenous peoples disappeared across the landscape. Thus, widespread regional extinctions of the Yam Daisy, extinction of *C. albipes*, its habitat and food; and the demise of the cultivation practices of the traditional owners were all rapid and contemporaneous.

Although relatively common in sub-fossil deposits across Bassian Victoria (>1% of bones) and discovered early in colonial settlement, *C. albipes* (Fig. 1) rapidly declined to extinction as European pastoralists and their sheep invaded *Australia Felix* (Fig. 2; Gould 1863; Menkhorst and Williams 1995; Norris *et al.* 1983). The Yam Daisy *Micoseris walteri* Gand. also suffered dramatic declines. The canons of Australian mammalogy, Wood Jones (1925), Troughton (1973) and Ride (1970), add little extra biology to that provided in the initial account by Gould (1863). The Victorian compilation of Brazenor (1932) did not mention the species but Williams and Menkhorst (1995) and Seebeck and Menkhorst (2000) provided a few additional historical records/observations from central–western Victoria. It has been described as 'nowhere abundant' (Gould 1863, p. 2) to the 'common rat of the country' (Goulburn River area) by John Cotton in 1846 (quoted in Seebeck and Menkhorst 2000, p. 359). Here we endeavour to connect some of the dots around *C. albipes*, a 'zoological ghost' of colonial times.

An astute observer of both nature and Indigenous societies, AW Howitt was well acquainted with *C. albipes* and collected the only specimens held in Museum Victoria (=2; NMV C 8585-6). These were probably from Gippsland as he also recorded the word for the species used by Braiakalung speakers, (members of the GunaiKurnai language group of Gippsland) (Mansergh and Hercus 1981). In the *Native Tribes of Aborigines of south-east*

Fig. 1. Illustration of *Conilurus albipes* from Gould 1863. The very early vernacular, Rabbit-rat, was much later attributed to the large ears of *Conilurus* spp., however, other species such as bilbies and bandicoots have relatively much larger ears. It is likely that the 'rabbit-rat' of early shepherds and settlers may have referred to its edibility, rather than its ears.

Australia, Howitt (1904) recorded the Rabbit-rat as a totem of the Ngarigo, Ya-itma-thang, Yuin and Wolgal language groups of eastern Victoria and south-eastern NSW (Fig. 2). These latter records have remained hidden in plain view for over 120 years! As a totem the *Tchuteba*, would have been significant in the social organisation, economy and spiritual life of these Indigenous people over substantial areas of south-eastern Australia, centred on the eastern Great Dividing Range.

Evidence provided in *Dark Emu* (Pascoe 2014) indicates that Indigenous economies involved much more husbanding/cultivation of the land than has been previously recognised. Cultivation could extend over many square kilometres. In contrast to more western language groups, Indigenous groups of the southern uplands were more dependent upon tubers, particularly the Yam Daisy, and less on grains (Flood 1980). These peoples had *Tchuteba* as a totem and we know adjacent language groups' name for it. We suggest that increased dependence on Yam Daisy of these language groups may have elevated the associated *Tchuteba* to totemic status — ensuring a defined segment of the tribe would not injure it. This totemic significance has not been found in other language groups, but full lists of tribal totems from historical records, including Howitt (1904), are scanty (at best).

This evidence consolidates the past known distribution of *C. albipes* but, more importantly, raises questions around the association of the species with Indigenous cultivation/economy and the rapid, contemporaneous demise of both. On the basis of all available evidence, a plausible explanation is presented here.

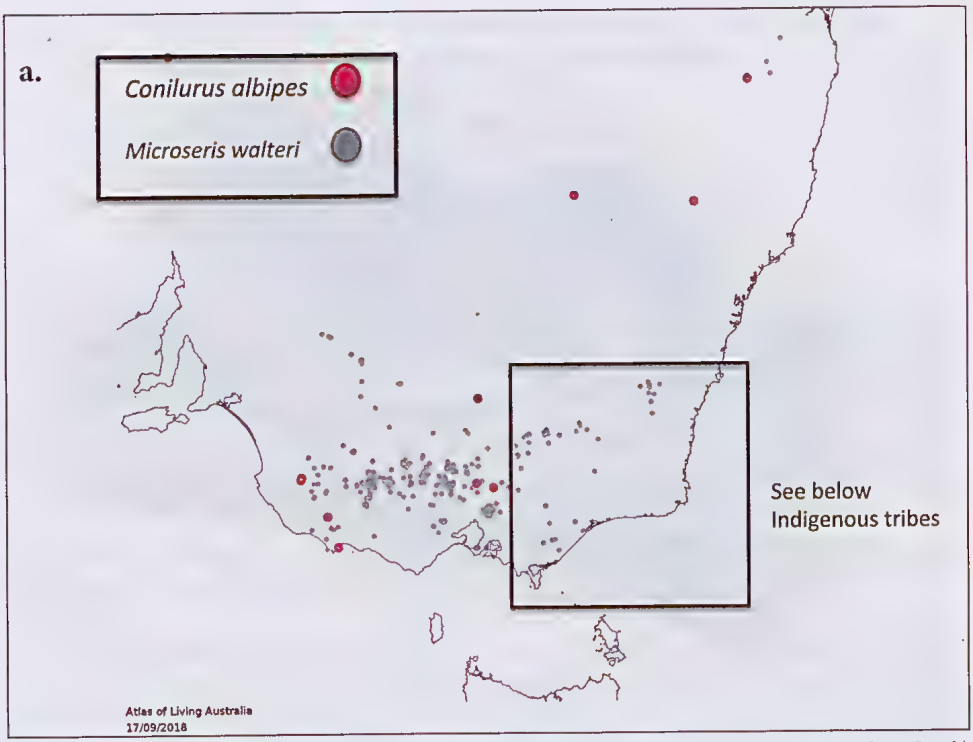

Fig. 2a. Distribution of *Conilurus albipes* records in Australia and the Yam Daisy (*Micoseris walteri* Gand.) Data from Atlas of Living Australia (13 Sept. 2018). See also distribution of *M. walteri* in Walsh (2016).

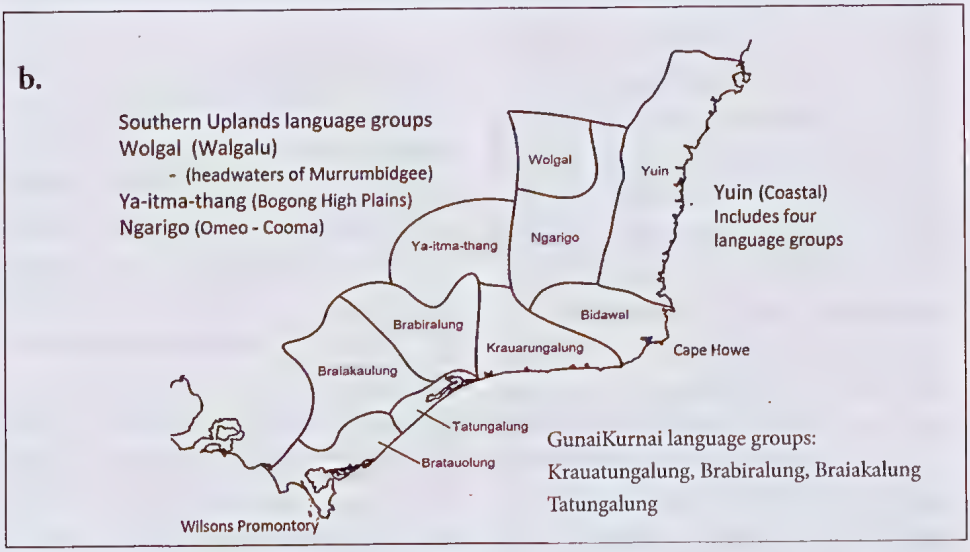

Fig. 2b. Indigenous language groups that had *Tchuteba* as a totem and where it was recorded in language, following Howitt (1904).

***Conilurus* — diet and Indigenous cultivation**

The larger species in the Conilurini tribe are 'old endemics', all nocturnal and nest in tree hollows. Although the diet of *Conilurus albipes* remains unknown, the closest relatives (*C. penicillatus, Mesembriomys gouldii, M. macrurus*) are all vegetable eaters (Strahan 1983) and the smaller *Pseudomys* species are predominantly seed eaters. It is almost certain that *C. albipes* was vegetarian, probably eating tubers and seeds across the year. Perhaps significantly, the very few early records of the larger Golden-backed Tree-rat (*M. macrurus*) *and C. albipes* are associated with being pests in food stores of early settlers. These large rodents were apparently not 'shy' around human food management (McKenzie 1983, Williams and Menkhorst 1995). At least one conilurine, *Leporillus apicalis,* was 'tender and well tasted' (G Krefft, quoted in Gould 1863, p. 4) and all were probably part of Indigenous diets.

The habitat of *C. albipes* has been described in terms of the 'natural environment' — open forest and woodland (Gould 1863, Williams and Menkhorst 1992), with Wood (1925) noting a propensity for fertile soils, such as cultivated by Indigenous peoples. The few Victorian records are derived from mesic (riverine) habitats and skeletal remains from the Snowy River Gorge (Norris *et al.* 1983), thus correlating with valleys where Indigenous settlement was concentrated (Flood 1980). In 1846 (a few years after sheep arrival), it was 'the common rat' of the country along the Goulburn River downstream of Yea but within a few years it was extinct (Williams and Menkhorst 1995). These localities/topographies are consistent with Indigenous cultivation sites as described by early explorers and compiled in Pascoe (2014). Importantly, extinction occurred decades before the introduction of the Red Fox *Vulpes vulpes,* although domestic (and early feral?) cats were known to have preyed upon *C. albipes* (Menkhorst and Williams, 1995).

The Yam Daisy was the staple root crop extensively cultivated by many of the Indigenous language groups in south-eastern Australia who also cultivated grasses for grain (Gott 2008; Pascoe 2014). The continental distribution of *C. albipes* is enclosed by that of the Yam Daisy (Fig. 2, Walsh 2016). We suggest that over the millenia, the Indigenous owners cultivated the original habitat of *C. albipes* allowing this larger rodent to exploit the concentration of food resources (such as Yam Daisies and grains) and the resultant populations became a readily available food resource for Indigenous peoples. The size and hollow log/prostrate branch dependence of *C. albipes*, would have made it a readily available animal protein as part of the Indigenous cultivated landscape (Gould 1863). We suggest, that by the time of European arrival, its distribution was strongly associated with Indigenous cultivation—within the fertile parts of the landscape—the open grassy woodlands. Rodents associations with the disturbances of 'agricultural' humans are well known elsewhere, and have been established in a much shorter time-frame than available on the Australian continent (e.g. Black Rat *Rattus rattus*, House Mouse *Mus musculus,* Harvest Mouse *Micromys minutus*). Indeed the converse, that a species ignored a relatively concentrated food source within its habitat, appears unlikely.

The taxonomy of the three local *Microseris* species has been recently reviewed by Walsh (2016). *Microseris scapigera* is rare in Victroria and largely confined to the lowland basalt plain in the west of the state and *M. lanceolata* is largely restricted to alpine–subalpine areas. The language groups traded in seeds and tubers to enhance their cultivars (Pascoe 2014). *Microseris walteri* is currently the most tuberous of the species and is now rare/extinct on the Victorian basalt plains, with the remnant Yam Daisies (*M. scapigera*) not noticeably tuberous. Indeed, *Microseris* as a crop disappeared from the basalt plains within 1–2 years of the arrival of sheep. So did the Aborigines cultivate a tuberous selection of *M. scapigera* or was it a cultivar of *M. walteri* that would survive on the basalt only with Aboriginal cultivation? Either or both are now very rare, if extant on the basalt plain, which suggests that what was cultivated was solidly reliant on Aboriginal cultivation practices.

The identity and origin of the *Microseris* cultivar that was so important in these practices are unknown. Almost certainly Aboriginal cultivation of Murnong was not based on extant genotypes of Yam Daisy but was of a cultivar inevitably developed over millenia of

careful husbandry. We do not know whether this cultivar was developed from one of the currently-recognized three species of *Microseris* or involved hybridization amongst these species. For a discussion of the development of cultivars from wild plants see Zohary and Hopf (1994). Nevertheless, it is likely that the Yam Daisy cultivar would only survive on the basalt through Aboriginal cultivation. When these Aboriginal agricultural practices ceased, then the cultivar disappeared as well.

Conilurus albipes range and the squatters

In the 19th century 'woodlands' sometimes had the English meaning (i.e. a treed landscape, often forested), but it appears that the few commentators who mentioned *C. albipes* were careful to distinguish its habitat as treed and relatively open (i.e. **not** forested). Woodlands (in the current sense) are the typical vegetation type (in south-east Australia) on fertile soils (e.g. Red Gum Woodlands of the basalt). This suggests that *C. albipes* was an inhabitant of fertile but openly treed landscapes, in a sense pre-adapted to developing Aboriginal agriculture. *Conilurus albipes* is yet another rodent that may have exploited the developing agricultural landscape and become both more common but also an important component of the whole Aboriginal agricultural landscape. Their agricultural landscapes remained treed, for a number of reasons perhaps, including wanting to keep *C. albipes* in the landscape as part of the animal husbandry they practised.

These Indigenous cultivated sites were the most attractive to sheep and thus early squatters/settlers. Sheep preferentially grazed Yam Daisies including the root, and compacted the soil impeding regeneration. Yam Daisies rapidly disappeared wherever sheep grazed the landscape. Thus a staple dietary item of the Indigenous people was eliminated as was evidence of their cultivation—soil fertility and structure (compacted by ungulates). We contend that extinction of *C. albipes* was another component of this ecological and cultural catastrophe. That there were no apparent 'natural refugia' for *C. albipes* to persist also indicates that the species had probably evolved quite specific habitat preferences — precisely that which would be favoured by early European settlers and their sheep. Settlement was particularly rapid in all the fertile grassy woodlands. For example, in less than 5 years from the arrival of European settlers in Melbourne, the fertile open grassy woodlands of the Campaspe Plains (>100 km north of Melbourne) were fully occupied by graziers and their stock (Munro 1842).

Throughout south-eastern Australia, woodlands were preferentially settled very early. This involved squatters placing stock and shepherds in the grassy woodlands, where the shepherds were left largely to fend for themselves (e.g. construct their own shelters and procure a lot of their protein from the landscape).

The rural population of the UK had a long history of using squirrels/rabbits as food. A colonial shepherd with experience of rural life in Europe would have also looked to the local squirrel analog for their meat. Its occupancy of low hollows made *C. albipes* easy for shepherds and settlers to capture. Although the vernacular for *Conilurus* was later attributed to their 'long' ears (Strahan 1983), it seems equally, if not more, plausible that its early discovery and naming (Gould 1863) alluded to its edibility rather than its ear size (see Fig. 1). The current official, and posthumous, name is now Tree-rat (Dixon 1998).

So we have preferential settlement in the prime *C. albipes* habitat, compounded by heavy hunting pressure from the European shepherds and settlers, compounded on the sudden loss of Aboriginal husbandry. That's not a good recipe for survival of *C. albipes*, long before red foxes and rabbits were introduced and regardless of the impact of feral cats. This scenario is more satisfactory than all previous explanations (foxes: Troughton 1973; climate change: Dixon in Gould 1863, or just the non-explanatory 'European settlement': many authors).

Tchuteba's environment in the Southern uplands

AW Howitt (1904) provided a comprehensive anthropological study of the Indigenous language groups of south-eastern Australia and recorded the totems of many language groups. A totem may have several uses/ meaning within the broader context that man and other species are both part of the social and ceremonial whole — reinforcing the world view that there is no

dichotomy between man and nature. Here, we use the term to mean the social or territorial totems that underpinned the social organisation of the language groups (*sensu* Howitt 1904) – 6 to 9 totems being under the primary moieties of eaglehawk and crow (see Christie 1979, Howitt 1904). A person may have had several totems, the understanding being that as your totem(s) cared for you, your obligation was to reciprocate that care.

Tchuteba was a totem of the Ngarigo and Wolgal language groups of the Australian Alps –Monaro region. It was also a totem of the adjacent Ya-itma-thang and Yuin language groups but their early disruption precluded complete listing of totems by Howitt (1904) (Fig. 1: location of language group). The species was also known to the GunaiKurnai people of Gippsland (Mansergh and Hercus 1981). Many animal totems were significant food sources for these language groups and/or apex predators (Lace Monitor, Eaglehawk and Dingo) (see Howitt 1904; Flood 1980). The small to medium sized mammals, including *Tchuteba*, were nocturnal and hollow dependent, and thus readily captured. The generic term 'rat' was often noted as an Indigenous dietary item (e.g. Flood 1980). Its large size, edibility, ease of capture (low hollows) and proximity to cultivation make *Tchuteba* a prime protein candidate. Mammal food resources available to the language groups of the southern uplands were listed by Flood (1980: Appendix IIIB), but she includes only extant mammals, not *C. albipes*.

Flood (1980) concludes that the language groups of the southern uplands were more dependent on the Yam Daisy and other tubers than language groups further west, as there was a dearth of suitable grain species (and she found fewer grinding stones). These language groups were certainly cultivators (Pascoe 2014). Increased relative dependence on the Yam Daisy and other tubers may have raised the associated *Tchuteba* to totemic status in these language groups.

Less than five years after the arrival of sheep, Lhotsky (1834, in Hancock 1972), the earliest scientific observer of the Monaro district, noted the depauparate nature of Aboriginal people, the soils and the native pasture. The first official stock 'count' (1848), in the Monaro region recorded > 0.5 M sheep and cattle [in 1856 there would only be <3000 Europeans in the broader region] (Hancock 1972, Brodribb 1978). The yam daisy (*M. lanceolata*; Mewan in Ngarigo) still persists in subalpine areas but is now very rare or absent in areas used for pastoralism (Gott 2008; ANBG website <https://www.anbg.gov.au/apu/plants/micrlanc.html>). The species and areas where Aborigines cultivated were targeted by settlers for their sheep (mostly) and cattle. Regional extinctions of the yam daisy were rapid following the arrival of sheep and cattle (Pascoe 2014). The extent and speed of the sheep invasion that eliminated a staple food source of the Indigenous peoples and *C. albipes* are hard to underestimate (Munro 1842).

The situation in GunaiKurnai country was later but very similar. In 1842 Brodribb saw Gippsland devoid of stock, but by 1844 the region supported >62,000 sheep and >20,000 cattle that had come mainly down through the Monaro (Flood 1980; Hancock 1972; Brodribb 1978). Although the upland language groups were not devastated by the smallpox epidemic until 1830, they were depleted by syphilis and other exotic diseases (Flood 1980; Hancock 1972) so the rapid loss of their primary food source was in a context of already much depleted populations.

Conclusion

Indigenous knowledge and the ethno-historical record hold a wealth of ecological information that will increase our understanding of the Australian environment. Over the millennia in south-eastern Australia, Indigenous people cultivated the rich fertile soils of the woodlands, which were, we argue, the original habitat of *C. albipes*, which exploited the consequent resource concentration and itself became a food source. The extinction of *C. albipes* and continental decline of the Yam Daisy were rapid after the arrival of sheep, which favoured these cultivated landscapes. *Conilurus albipes* had no other refugial habitat. Thus a staple, cultivated dietary item of the Indigenous people was eliminated, along with evidence of their cultivation, including soil fertility and structure. These inter-relationships help explain the extinction of *C. albipes* — another component of this rapid ecological and cultural

collapse. More locally, the language groups of the southern uplands had increased reliance on the cultivated Yam Daisy and thus the associated *Tchuteba* achieved totemic status. Although some may find this interpretation somewhat speculative, we believe it provides a coherent explanation of all the known information, including the recent remarkable revelations of our historical context in publications such as *Dark Emu* (Pascoe 2014). Fortunately an active research and rehabilitation project on Yam Daisies is being undertaken in conjunction with indigenous people in south-eastern New South Wales (National Landcare Program website <http://www.nrm.gov.au/Indigenous-nrm/south-east-nsw/yamflowers>).

Acknowledgements

This article is dedicated to the late Lance Williams, a great ecologist and friend who amongst many other things compiled the account of *C. albipes* in *Mammals of Victoria*. We thank Neville Walsh (Royal Botanic Gardens Victoria) and John Morgan and Zac Walker (both of La Trobe University) for comments and compilation of the language map respectively.

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Ants collecting pieces of a bird dropping at Notting Hill, Victoria

Splat! On the morning of 29 December 2018, a sizeable bird dropping, probably from a north-bound Little Raven *Corvus mellori*, hit the south-facing wall of our house. Humid weather and shady conditions ensured that the dropping didn't dry out. Before long, dozens of White-footed ants *Technomyrmex albipes* arrived (Figs. 1 and 2), industriously removing tiny pieces from the dropping and carrying them to their nest.

After several hours, more than half the mess had been taken away, and the ants had stopped their work. Showery conditions the following morning allowed the remains of the dropping to stay damp. The ants returned, and by afternoon most of the dropping had gone (Fig. 3). Not much cleaning up to do now.

Fig. 1. White-footed ants *Technomyrmex albipes* attracted to bird dropping, Notting Hill, Victoria.

White-footed ants are introduced pests (Simon Hinkley, pers. comm., 6 February 2019). They are native to the Indo-Pacific region and were first described in 1861 from Sulawesi, Indonesia, by British entomologist Frederick Smith. They have been introduced into Australia, Africa, North America, the Caribbean and parts of Asia. They have the ability to reproduce in large numbers, and colonies can contain millions of individuals (Wikipedia website 2018).

The reason for collecting and/or feeding on bird droppings depends on the species of ant. To date I have found no detailed information about bird droppings in the diet of ants in Australia. However, a lot of research has been done overseas, particularly in the Americas, with very interesting results, a few of which are worth mentioning here.

Some ants collect seeds from the droppings of frugivorous birds (Kaspari 1993; Christianini and Oliveira 2010). Fire ants *Solenopsis geminata* have been observed feeding on Blue-gray Tanager *Thraupis episcopus* droppings containing poorly digested papaya pulp (Sainz-Borgo 2015). Other ants feed on bird droppings (which contain waste nitrogen in the form of uric acid) in order to obtain a supply of nitrogen in their diet. In Turtle ants *Cephalotes* spp., various symbiotic gut bacteria recycle uric acid from bird droppings, synthesising essential amino acids that are then digested by the ants. This has been going on for at least 46 million years (Hu *et al.* 2018). In Carpenter ants *Camponotus* spp. the symbiotic bacteria (genus *Blochmannia*) that recycle nitrogenous waste are actually intracellular, occurring in both the gut and the ovaries (Hu *et al.* 2018).

One species of Turtle ant, *Cephalotes atratus*, is involved in the remarkable life-cycle of a parasitic nematode (roundworm) *Myrmeconema neotropicum* (Poinar and Yanoviak 2008; Yanoviak *et al.* 2008). The nematode eggs are present in droppings from frugivorous birds. Ants collect droppings and feed them to their larvae, a small percentage of which become infected. By the time the infected larvae have developed into adult ants, the nematodes have hatched and mated, and the ants' gasters (abdomens) are full of gravid female nematodes. At this stage the gasters, which are normally black, turn red, resembling berries that grow in places

Fig. 2. White-footed ants (detail).

Fig. 3. Most of the bird dropping has been removed.

where these ants live. It is thought that frugivorous birds eat the infected berry-like gasters, which break off easily. The eggs from the gravid female nematodes pass through the birds' digestive system, are excreted in the droppings and then collected by ants.

I don't know why the ants at our house were collecting pieces of bird dropping, but since they seemed to be interested primarily in the white part, which contains uric acid, they may have been seeking nitrogenous material. It was disappointing to learn that they were introduced pests, but what a pity they didn't find—and remove—an even larger bird dropping that landed on one of our window panes (Fig. 4). Plenty of cleaning up to do there.

Fig. 4. Large bird dropping on window pane.

Acknowledgement

Thank you to Simon Hinkley, at Museums Victoria, for identifying the ants.

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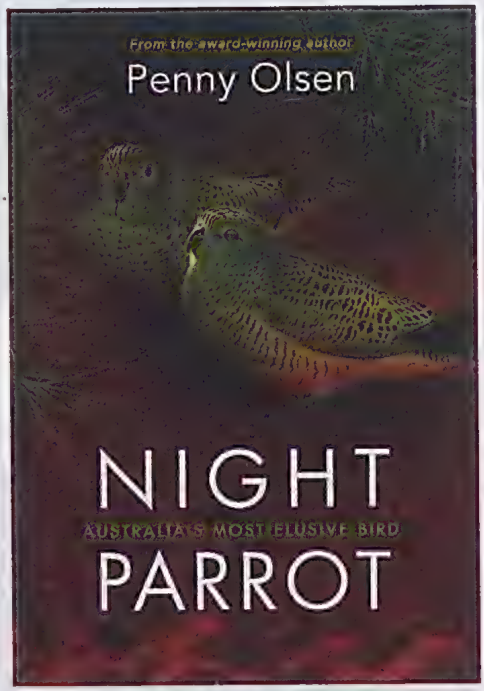
Night Parrot: Australia's most elusive bird

by Penny Olsen, with chapters (essays) by Peter Curry, Stephen Garnett, Bruce Greatwich, Leo Joseph, Glenn Holmes, Emma Lindsay and Robert Nugent

Publisher: *CSIRO Publishing, Clayton South, Victoria, 2018. 360 pages, paperback. ISBN 9781486302987. RRP $49.99*



Australia hosts many faunal mysteries, such as the speculation regarding remnant populations of Thylacine[1]. Over the last few centuries, Euro-ornithology has slowly unravelled many avian puzzles, such as the breeding location of the Banded Stilt *Cladorhynchus leucocephalus*, once thought to be overseas rather than the almost unimaginable reality of sporadic mass breeding in remote inland wetlands. However, one of the most persistent secrets, evoking some of the most extreme investigations, centres around the search for the Night Parrot *Pezoporus occidentalis*—a search which must rank among the world's greatest biodiversity treasure hunts. This beautifully written and presented book provides a gripping account of the unfolding human and ecological story of the search and 'discovery' of one of Australia's most mysterious animals. This story is shrouded in mystery, personalities, and intrigue. It will interest not only those who are ornithologically inclined but—given the circuitous and sometimes bizarre twists and turns—it should also interest anybody who enjoys reading thrillers, history or character-driven narratives. This book reminds the reader that fact can be stranger than fiction!

The book is mainly structured as state-by-state accounts, rigorously retelling prominent events and introducing people (mostly men as Olsen points out) whose stories have been interwoven with that of the parrot. Chapters also cover genetics, habitat conservation and management, and the recovery and research effort that will underpin the future of this enigmatic species. Key players in the story have contributed, though the controversial character John Young (who relatively recently discovered nests and captured a live parrot, which he photographed and videoed) did not contribute directly, despite being invited to do so. The artwork is simply beautiful, and the photographs are delightful (both ancient black and white images and sharper, more recent offerings). Quotations abound, and references appear as endnotes, so as to not interrupt the flow of the expertly crafted text. The text is accurate, critical and balanced; it is also engaging and enthralling.

As you can tell, I am extremely enthusiastic about this book! Declaring potential conflicts of interest when reviewing books is important, and I confess to two. Firstly, Penny Olsen and I worked on many projects together, and co-wrote a series of *State of Australia's Birds* reports; I regard Penny as the best writer I have ever worked with (evidenced, I argue, by this wonderful book and her numerous literary

awards and achievements). Secondly, I confess that I fell into being 'one of those parrot pursuers'; so numerous are we that *Night Parrot* could never tell every story (clearly acknowledged by the author). However, I am inspired by the book to share a few personal tales. Around the corridors of BirdLife Australia in the 1990s (then known only as the Royal Australasian Ornithologists Union), staff knew of the office volunteer who quietly, carefully, and thoughtfully described seeing a Night Parrot fly over her campfire in the arid interior. I sat in my office at Moonee Ponds, exasperated at how I could write a text on the movements of Night Parrots for the *Handbook of Australian, New Zealand and Antarctic Birds*, finally settling on 'unknown but speculation abounds'—a statement which holds true for most aspects of the species for most of the last hundred years or so! Later, while I was Research and Conservation Manager at the same organisation, members would, from time to time, mount expeditions in search of the 'holy grail' and would sometimes discuss their plans with me. The purchase of Newhaven Station as a bird reserve, with its famous water trough sighting, piqued my imagination as it did for so many others. Then, interest turned into something more. Five years or so ago, a colleague of mine with impeccable skills and a lifetime of experience with parrots, reported seeing a parrot fly by at dusk in one of Victoria's desert parks, and in a classic understated way said 'Mike, it was definitely a parrot, and not a species I have seen before. I am not saying it was, but it could be nothing other than a Night Parrot'. Now working at a university, I immediately lent him thousands of dollars' worth of remotely-triggered cameras to monitor nearby waterholes. One tempting picture, and the theft of eight cameras later, we gave up. Our picture had all the hallmarks of typical Night Parrot evidence available to that date; it was vague, out of focus, ambiguous, and on the balance of probabilities almost certainly a species vastly better known. My experience with Night Parrots was not all positive. I had come to resent the secrecy and distrust of many of the more active searchers; like miners protecting their seam of gold, they sought counsel and support but brought suspicion and perhaps even paranoia into the conversations. Those who believed they had seen the species often remained silent, or nearly so, to avoid potential ridicule under the glaring blaze of 'cross-examination' from the ornithological community. I will never forget how I watched my social media in awe as I saw John Young's indisputable videos of the species, then a nest, and later vision of parrots with radio-trackers. I reported unfolding events week-by-week to a hundred bewildered undergraduates, the majority of whom barely recognised the little, green, unremarkable parrot. I was reminded in reading this book, that I too had been hooked by the search for the Night Parrot, as had so many colleagues and friends.

Penny Olsen is to be congratulated for recognising and reporting the very complex and fascinating nature of the human part of this ecological story of discovery. The even-handed, well-rounded and critical account that this book offers is simply excellent. This is a must-have for any naturalist, historian, bird-enthusiast or treasure hunter! The book also reminds us that mysteries motivate and inspire so many. We live in a golden time with so much yet to discover about our remarkable fauna, and we are blessed that some species do not give up their secrets too readily.

[1] There is an ornithological connection here, as one of the more credible, recent sightings occurred during Latham's Snipe *Gallinago hardwickii* surveys in remote Tasmania.

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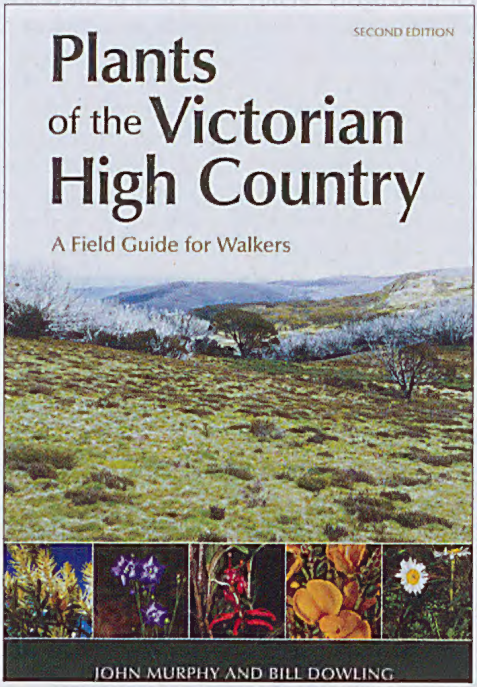
Plants of the Victorian High Country: A Field Guide for Walkers

by John Murphy and Bill Dowling

Publisher: *CSIRO Publishing, Clayton South, 2018. 2nd edition, 168 pages, paperback, coloured photographs. ISBN 9781486309016. RRP $39.99*



Plants of the Victorian High Country focuses on plant species most likely to be encountered by walkers in the area. These species tend to be the more obvious plants for a variety of reasons — for example, possibly they are common; have brightly coloured flowers, stems or foliage; or occur close to paths and/or camping sites. Whatever the reason, getting to know these plants allows for a greater appreciation and enjoyment of our beautiful High Country. An added advantage of becoming familiar with more commonly encountered species is the subsequent greater likelihood of seeing the more cryptic species in later travels, simply because the more species you are familiar with, the more able you will be to pick out a 'new' species. It will stand out **because it is not familiar.** For this reason alone, I applaud books such as this. Many times I have led field trips and many times I have heard the comment (or equivalent) 'I come here often and haven't seen half of what you've shown us'.

The book describes 133 species, 15 more than the first edition. Plant names and taxonomy have been updated, along with plant descriptions, to align with information provided in *Vicflora*, the plant database of the Royal Botanic Gardens Victoria. A welcome but brief account of Aboriginal people in the High Country has been added (p. x) and information on Aboriginal use of plants is provided for appropriate species, mostly courtesy of Russell Mullett, a heritage project officer with Aboriginal Victoria and a senior member of the GunaiKurnai Nation.

Following the introductory pages, the book is divided into three sections: The environment; Flower types; and Plant descriptions. Terminology is kept to a minimum but a glossary is provided for terms used.

The section on 'The environment' briefly describes the weather and the various altitudinal zones encountered. It may surprise some to realise that snow can persist for six months of the year on some of our sheltered southern and south-eastern slopes!

'Flower types' provides explanatory diagrams of the more unusual types of flower such as the daisies, peas, and orchids, as well as for the terms *actinomorphic* and *zygomorphic*, which relate to floral structure. I would have preferred the definitions, as provided in the glossary, be included as supporting text.

'Plant descriptions' are divided into five sections: Herbs (other than daisies); Daisy herbs;

Low woody shrubs; Tall shrubs and trees; and Eucalypts. First you need to determine which group your plant belongs to. Here you begin to understand that the colloquial usage of terms may mean something very different in the language of botany. If you know nothing of botany and this is your first venture into plant identification, you must realise that, botanically speaking, a herb (or herbaceous plant) is not something you use to flavour foods (such as Rosemary, a woody plant) but a plant that, simplistically, is not woody. Conveniently, the glossary tells you this. Once you have identified your plant group, go to the page shown in the index where a key will indicate the appropriate page/s to determine the name of your plant. However, you must remember, there is a possibility that your plant may not be represented in this book and, thus, you may not find a matching description for it. Don't be disappointed; you have found a species that others are likely to have overlooked.

The keys are extremely user friendly, simple and straightforward; the novice should not be afraid of using them. Occasionally a term may be used that is not found in the glossary, e.g. *trigger*, as occurs for the Trigger Plant *Stylidium armeria*. In this case, ask someone who has been into the High Country previously and they can explain it.

The information for each plant is accompanied by an excellent photograph or two, except for the Eucalypts. Information is succinct and relevant for easy identification. A general description of the plant is provided, as is the altitudinal zone in which the plant occurs, a specific description of the leaves and flowers, the flowering time, and, as appropriate, Aboriginal usage. One may be tempted to sample some of the delicacies, such as the Mountain Celery *Aciphylla glacialis*, which was eaten as a salad; the starchy tubers of the Pale Vanilla-lily *Arthropodium milleflorum*; Milkmaids *Burchardia umbellata*; or the corms of the Rock Lily *Bulbine glauca*. For dessert, the sugary stems of the Bogong Daisy-bush *Olearia frostii* can be chewed. But the authors provide a warning at the start, that many species are poisonous and strongly advise that none should be tasted without expert advice. It must also be remembered that there are protected flora controls and you are likely to require a permit to collect flora. Many species are protected, e.g. all daisies, epacrids, orchids, clubmosses, ferns, fern allies (with one exception), fringe-myrtles, *Baeckia* spp., *Boronia* spp. and many more! The other thing to remember is that the vegetation of our High Country is already stressed by and under increasing threat from climate change, weed invasion, and grazing by exotic animals. Depending on numbers, would-be-diners could add further stress and I recommend sourcing 'wild foods' from appropriate market places or going to a native plant nursery so you can buy the desired species and grow your own.

Plants of the Victorian High Country is a lovely and highly useable book, well worth its recommended retail price of $39.99. The book is quite light and a pleasurable addition to one's pack. It is aimed at walkers but I recommend it for anyone interested in alpine plants or those wanting to understand a little more of useful Aboriginal plants.

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